

CLAIMS

What is claimed is:

1. An ultrasonic probe comprising:

an elongate structure having a longitudinal axis;

a first array of ultrasonic transducer elements extending along an outer surface of said elongate structure in a direction generally parallel to said longitudinal axis;

a second array of ultrasonic transducer elements extending along the outer surface of the elongate structure in a direction generally parallel to said longitudinal axis; and

a third array of ultrasonic transducer elements extending about said elongate structure in a direction so that it images a plane perpendicular to that imaged by at least one of said first array and said second array, the third array being disposed in a space between said first array and said second array.

2. The probe of claim 1, wherein said first array, said second array and said third array are outwardly convex arrays.

3. The probe of claim 2, wherein said third array has a radius of curvature smaller than that of said first array and said second array.

4. The probe of claim 2, wherein said first array and said second array have a radius of curvature of substantially 60 millimeters.

5. The probe of claim 2, wherein said third array has a radius of curvature of substantially 10 millimeters.
6. The probe of claim 1, wherein said first array and said second array are configured so that beams formed by said first array and said second array subtend substantially thirty degrees of arc.
7. The probe of claim 1, wherein said third array is configured so that a beam formed by said third array subtends substantially 180 degrees of arc.
8. The probe of claim 1, further comprising a multiplexer for multiplexing connections to each of said first array, said second array and said third array.
9. The probe of claim 8, wherein said multiplexer is disposed within said elongate structure.
10. The probe of claim 1, wherein said first array and said second array are aligned so as to image a portion of a substantially continuous plan perpendicular to said plane imaged by said third array.
11. The probe of claim 1, wherein each of said first array, said second array and said third array are comprised of transducer elements having a resonant frequency of 6.5 Megahertz.
12. The probe of claim 1, in combination with a second probe, said second probe being capable of positioning so as to imaging in a plane perpendicular to a plan imaged by said first array and a plane imaged by said second array.

13. The combination of claim 12, wherein said second probe comprises transducer elements with a resonant frequency of 6.5 Megahertz.

14. The probe of claim 1, in combination with an electronics module, comprising:

excitation circuitry for providing excitation energy to said probe;

receiving circuitry for processing signals received by said probe;

signal processing circuitry for processing signals from said receiving circuitry to produce processed image signals; and

a display for displaying the processed image signals.

15. The combination of claim 14, further comprising at least one of:

frequency setting circuitry for setting a frequency of the excitation energy;

depth control circuitry for controlling the depth of images produced on said display;

gain control circuitry for controlling gain of said receiving circuitry; and

steering and focus control circuitry as a component of said signal processing circuitry for controlling the manner of operation of said signal processing circuitry.

16. The combination of claim 14, wherein said excitation circuitry comprises a table memory for providing values

of waveforms used to excite transducer elements of said probe.

17. The combination of claim 14, further comprising analog to digital converters as components of said signal processing circuitry for converting analog signals from said receiving circuitry into digital signals.

18. An ultrasonic imaging system comprising:

a first probe having:

an elongate structure having a longitudinal axis;

at least a first array of ultrasonic transducer elements extending along an outer surface of said elongate structure in a direction generally parallel to said longitudinal axis;

an additional array of ultrasonic transducer elements extending about said elongate structure in a direction so that it images a plane perpendicular to that imaged by said at least one first array;

a second probe having a further transducer array, said second probe capable of being positioned so as to imaging in a plane perpendicular to a plan imaged by said first array and said plane imaged by said additional array; and

an electronics module, said module having:

excitation circuitry for successively exciting said first array, said additional array and said further array;

receiving circuitry for processing signals received from said first array, said additional array and said further array;

signal processing circuitry for processing signals from said receiving circuitry to produce processed image signals; and

a display for displaying the processed image signals.

19. The system of claim 18, wherein said first probe further comprises:

a second array of ultrasonic transducer elements extending along said outer surface of said elongate structure in a direction generally parallel to said longitudinal axis, said second array also being excited by said excitation circuitry.

20. The system of claim 19, wherein said additional array is disposed between said first array and said second array.

21. The system of claim 18, further comprising at least one multiplexer for connecting each of said first array, said additional array and said further array to said electronics module for display of images.

22. The system of claim 21, wherein said at least one multiplexer comprises:

a first multiplexer for switching said electronics module between said first probe and said second probe; and

a second multiplexer for switching between transducer arrays of said first probe.

23. The system of claim 22, wherein said first multiplexer is a four to one multiplexer, which switches to a first half of transducer element of said further array, a second half of transducer elements of said further array, a first half of transducer element of a selected one of said arrays in said first probe, and a second half of transducer elements of said selected array in said first probe.

24. The system of claim 23, further comprising a second multiplexer for switching said selected array to be one of said first array and said additional array.

25. The system of claim 24, wherein said first probe further comprises:

a second array of ultrasonic transducer elements extending along said outer surface of said elongate structure in a direction generally parallel to said longitudinal axis, said second array also being excited by said excitation circuitry, and said second array is one of said selected arrays.

26. A method for medical ultrasonic imaging comprising:

placing a first probe having transducer arrays which image in two mutually perpendicular directions in a body cavity of a patient;

placing a second probe on an exterior surface of the patient so that a transducer array of said second probe produces an image in a plane perpendicular to each of the two mutually perpendicular planes;

exciting said probes; and

forming images using signals from said probe to visualize structures within the patient.

27. The method of claim 26, wherein said first probe comprises:

an elongate structure having a longitudinal axis;

a first array of ultrasonic transducer elements extending along an outer surface of said elongate structure in a direction generally parallel to said longitudinal axis;

a second array of ultrasonic transducer elements extending along said outer surface of said elongate structure in a direction generally parallel to said longitudinal axis; and

a third array of ultrasonic transducer elements extending about said elongate structure in a direction so that it images a plane perpendicular to that imaged by at least one of said first array and said second array, said third array being disposed in a space between said first array and said second array.